# Modeling plant species distributions under future climates: How fine-scale do climate models need to be?

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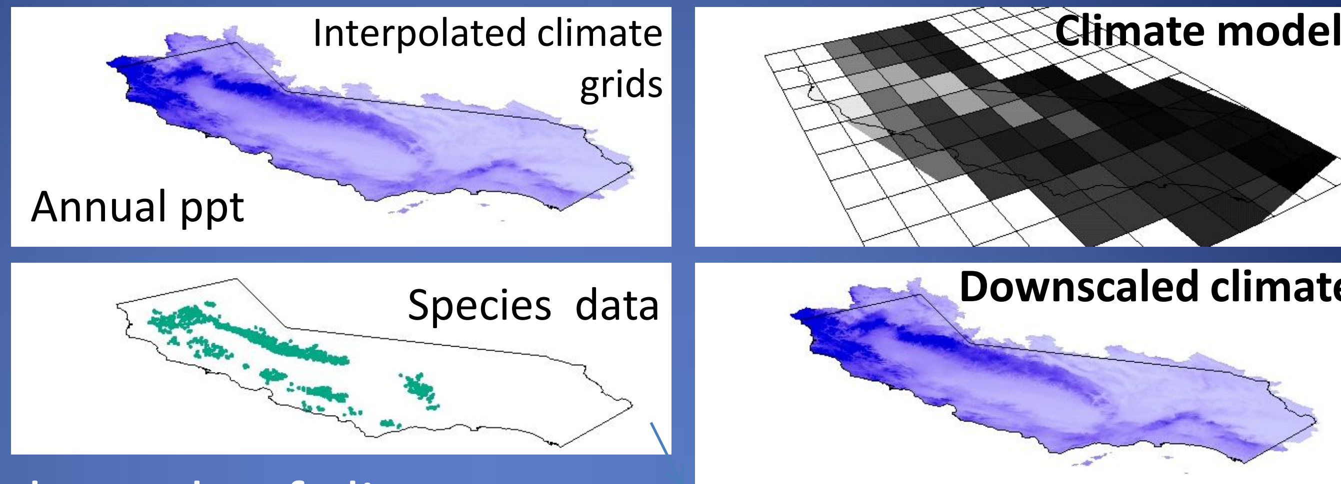
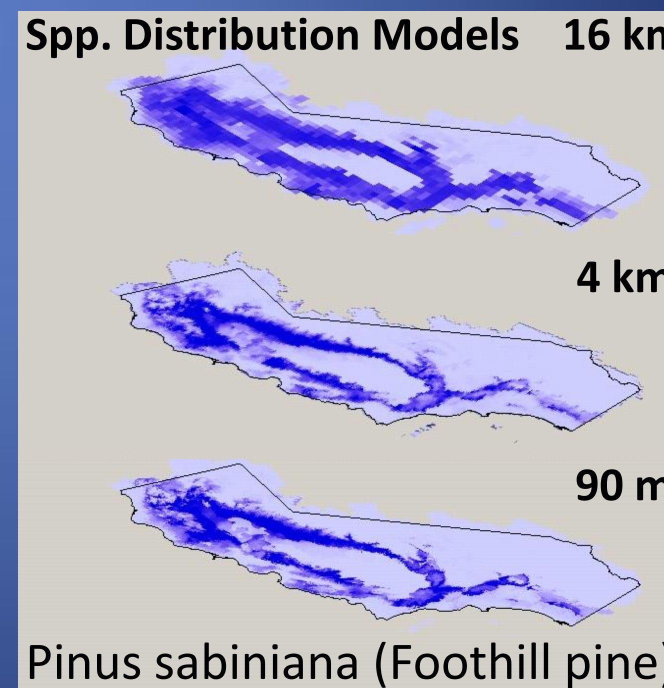
# Research Questions




- How does the scale of climate information influence modeled species distributions and projections of future range dynamics?
- How does analysis scale influence risk-based conservation priorities and adaptation strategies?

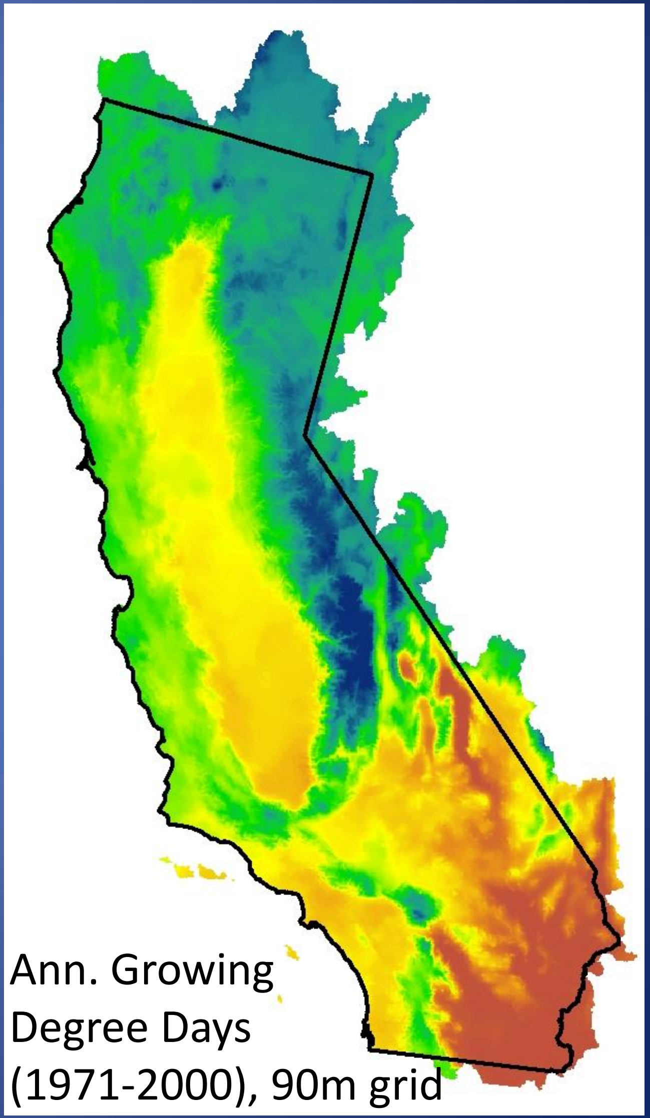


# Our Expectations

1. SDM accuracy will improve at finer scales (Seo et al. 2009)
2. SDM accuracy will be higher for species with smaller ranges (Syphard and Franklin 2009)
3. Modeled species range will increase with coarser climate data (Seo et al. 2009)
4. Modeled local species extinction risk from climate change will decrease based on finer scale data (Randin 2009, Austin van Niel 2010)

# Climate variables and study area

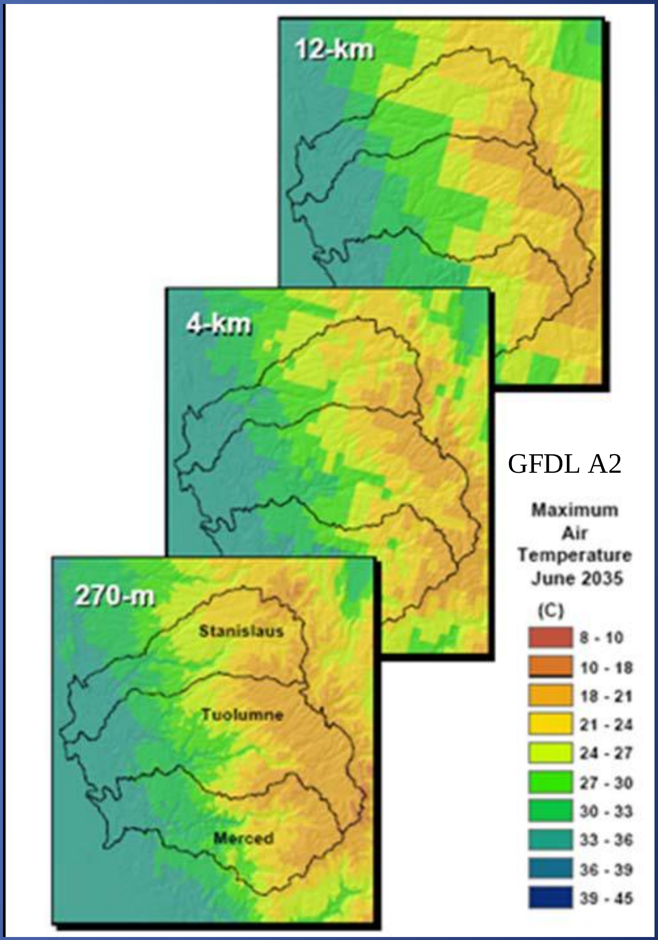
- 8 bioclimate variables
- 30 yr climate normals
  - Historical (1971-2000)
  - GFDL-CM2.1 A2, B1 (2041-2070, 2071-2100)
  - PCM A2, B1 (2041-2070, 2070-2099)
- 90m, 270m, 4 km, 16km grids



Ann. Growing Degree Days (1971-2000), 90m grid

# Climate downscaling

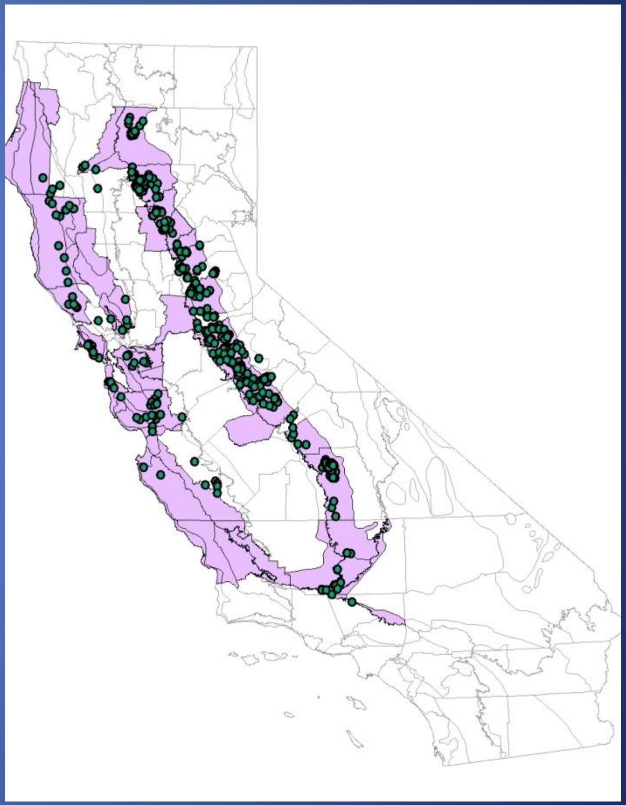
- Downscaling*
  - 2.5 deg to 12 km by constructed analogues (Hildalgo et al. 2007)
  - 12 km to 4km, 270m and 90m by gradient inverse distance squared method with bias correction
- Upscaling from 4 km to 16 km via linear interpolation




* **Flint, A.L. and L.E. Flint. 2010.** Downscaling future climate scenarios to fine scales for hydrologic and ecologic modeling and analysis. Manuscript in Review.

# Plant species distribution modeling

- 43 CA floristic province endemic species or infrataxa
  - Georeferenced plot and herbarium observations (14 < n < 9200 obs)
- Maximum entropy (MAXENT) distribution models
  - AUC for model goodness-of-fit
  - "Maximum sensitivity plus specificity" threshold for Presence/Absence



*Aesculus californica* (CA buckeye) Observation points over approximate range

**Narrow range (n=13)**
**< 10,000 km²**

**Intermediate range (n=12)**
**10,000 – 50,000 km²**

**Broad range (n=18)**
**> 50,000 km²**

**Photos**
**calflora.org**

Chorizanthe orcuttiana

Galium angustifolium

**Herb**
**n=8**

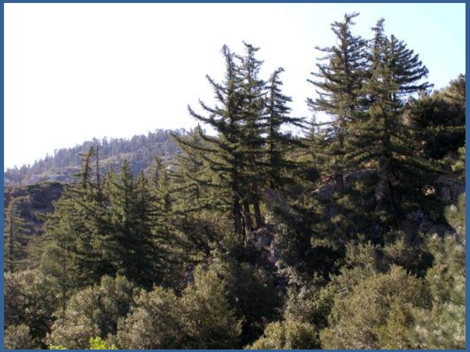
Quercus dumosa

Adenostoma sparsifolium

Ceanothus oliganthus

**Shrub**
**n=21**

Juglans hindsii

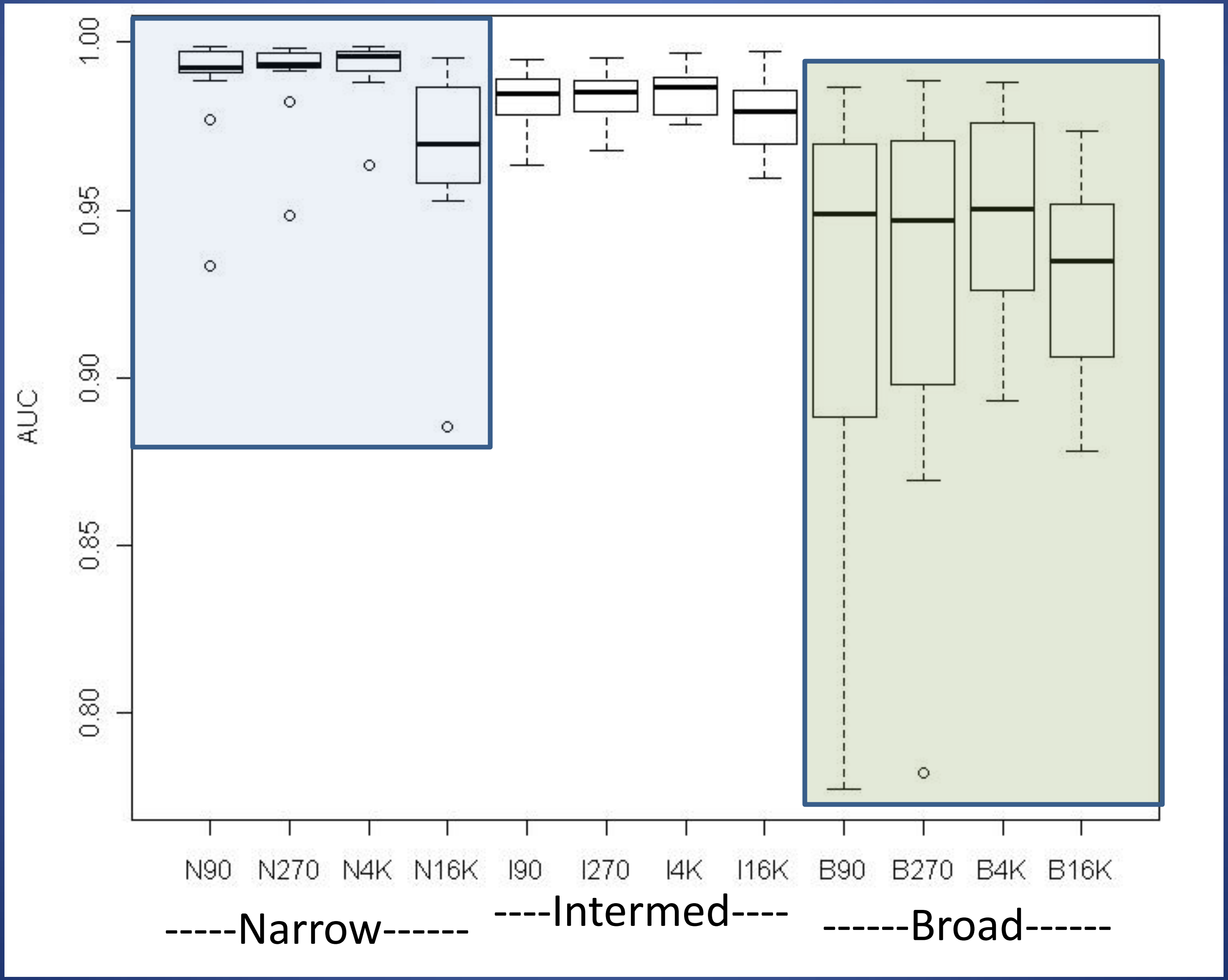


Pseudotsuga macrocarpa

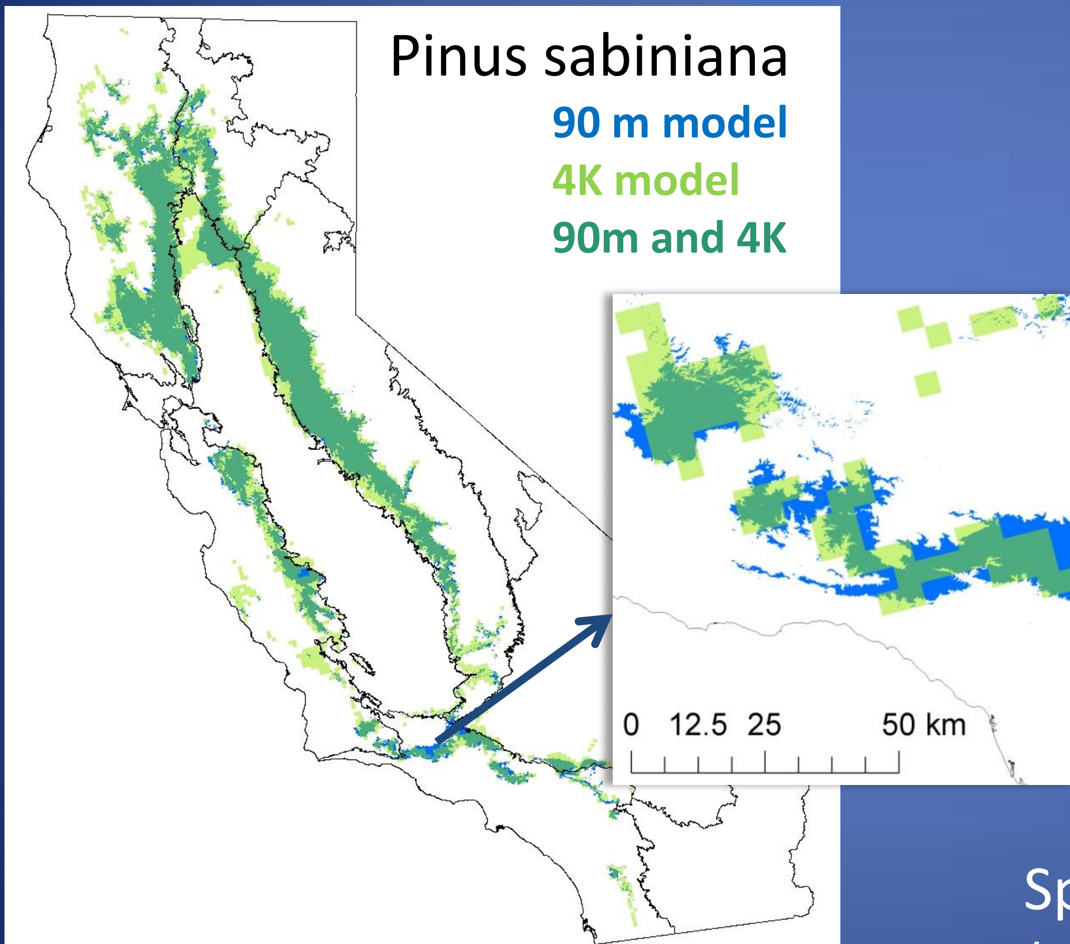
Pinus lambertiana

**Tree**
**n=14**

# Model fit to historical climate is better for narrow-range species, decreases between 4k and 16k scale



# Comparing modeled distributions across scales



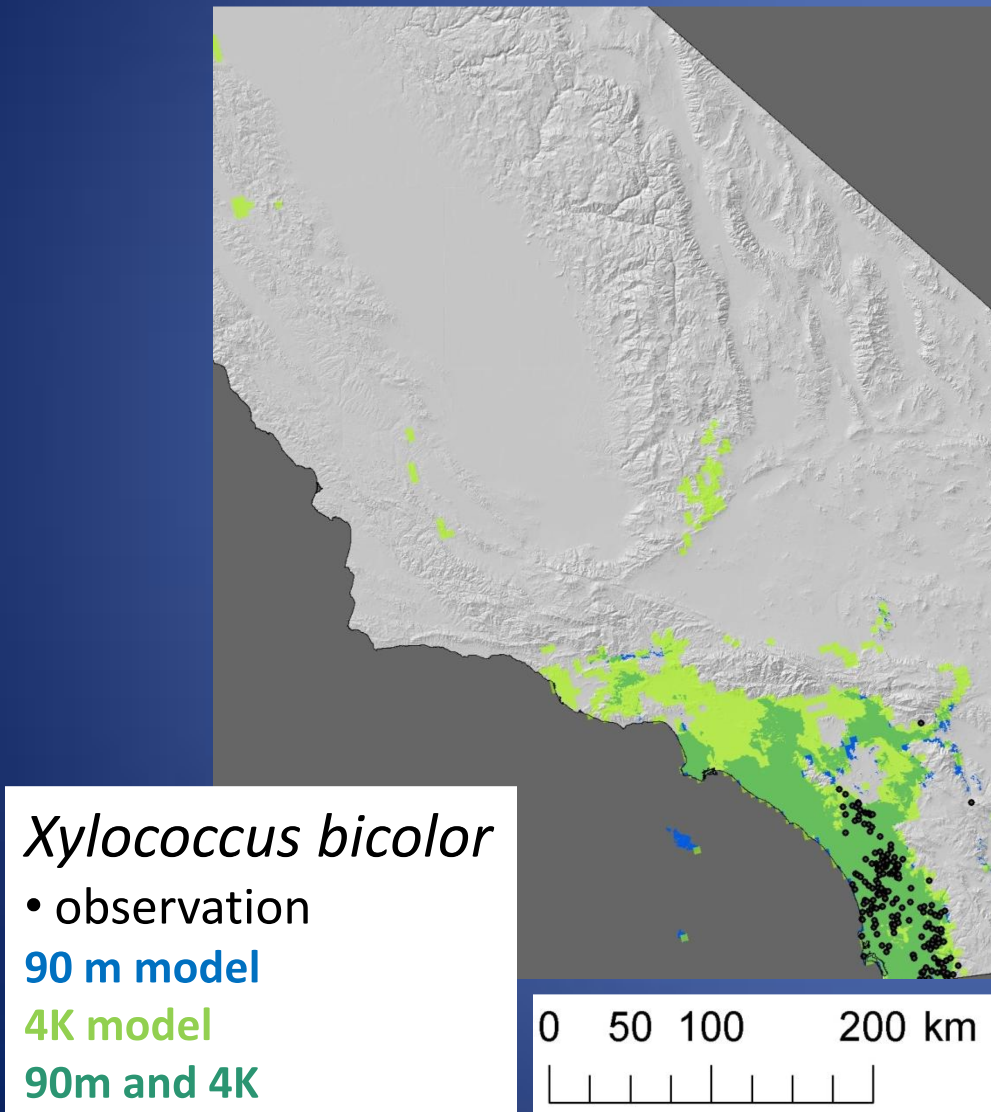

Fine scale

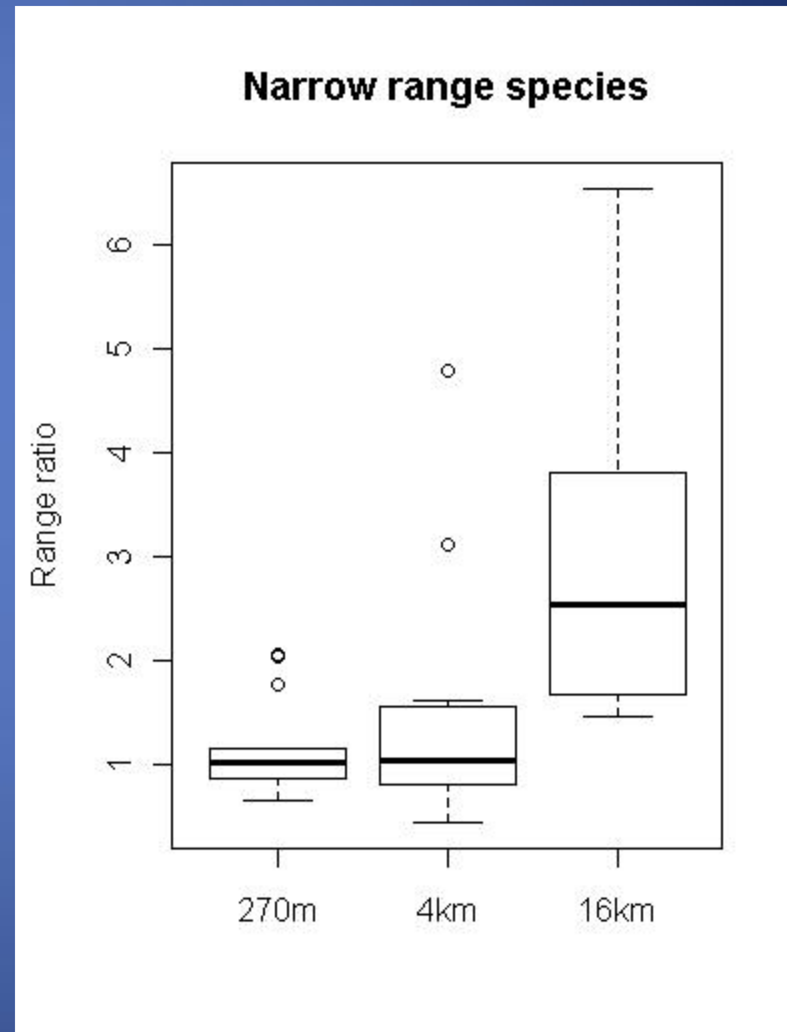
| Coarser Scale | | + | - |
|---|---|---|---|
| | + | a | b |
| | - | c | d |

Range ratio $\dfrac{a+b}{a+c}$

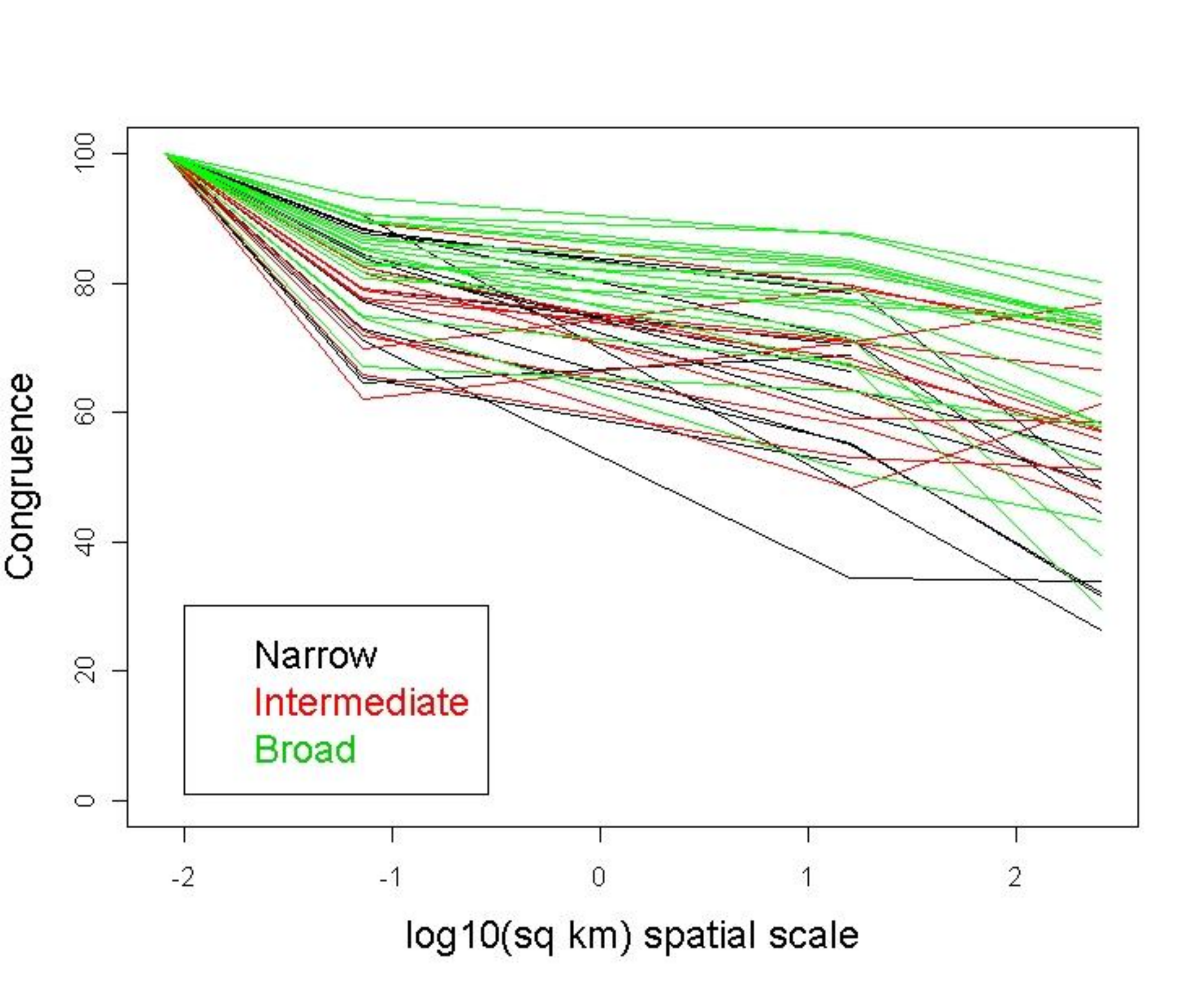
Spatial congruence (Dice-Sorensen) $\dfrac{2a}{2a+b+c}$

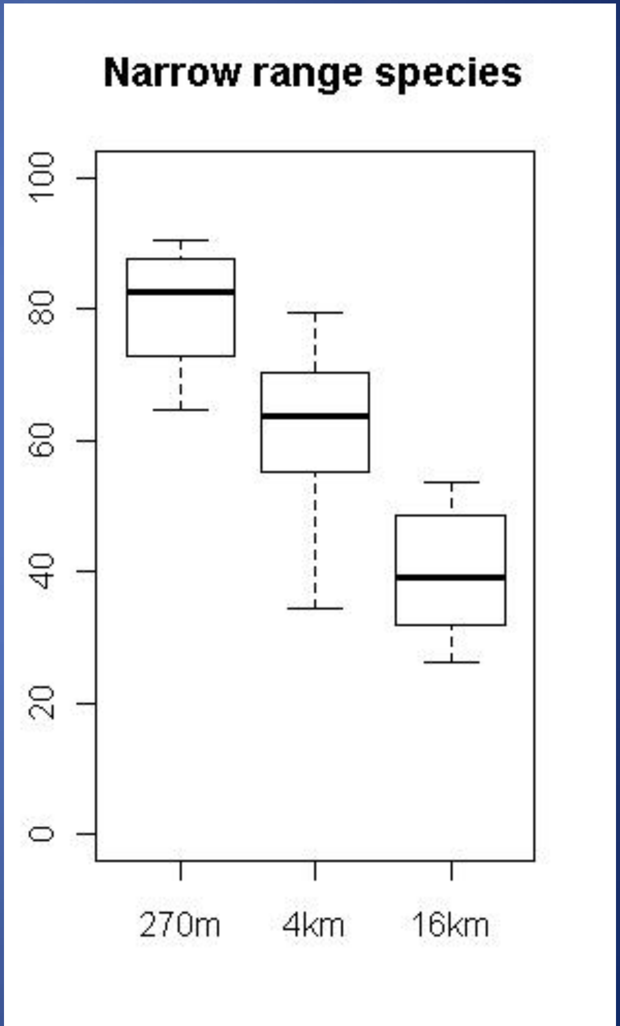
# Modeled range size increases only slightly from 90m to 4k; narrow endemics most sensitive



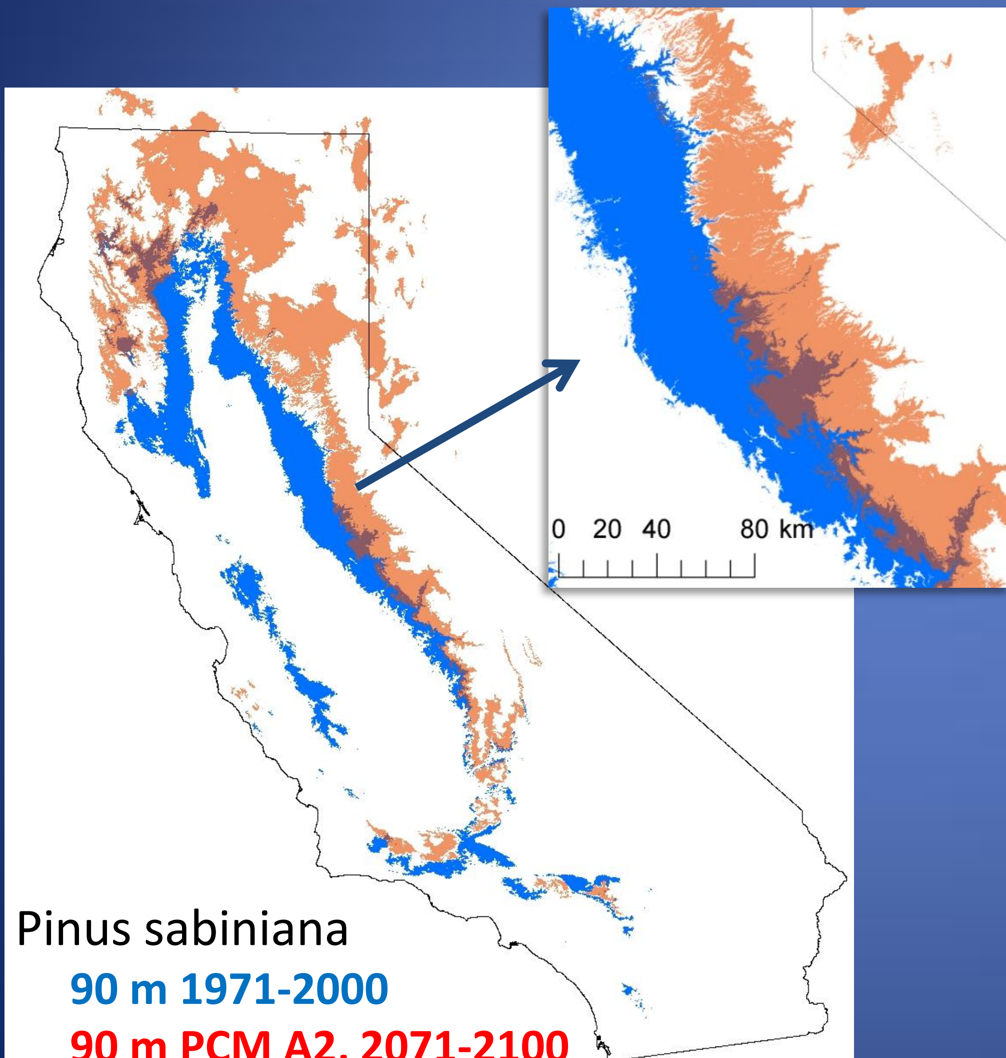



# Spatial congruence between range maps decreases steeply between 90m and 270 m



# Measuring scale-dependence of modeled range dynamics under climate change

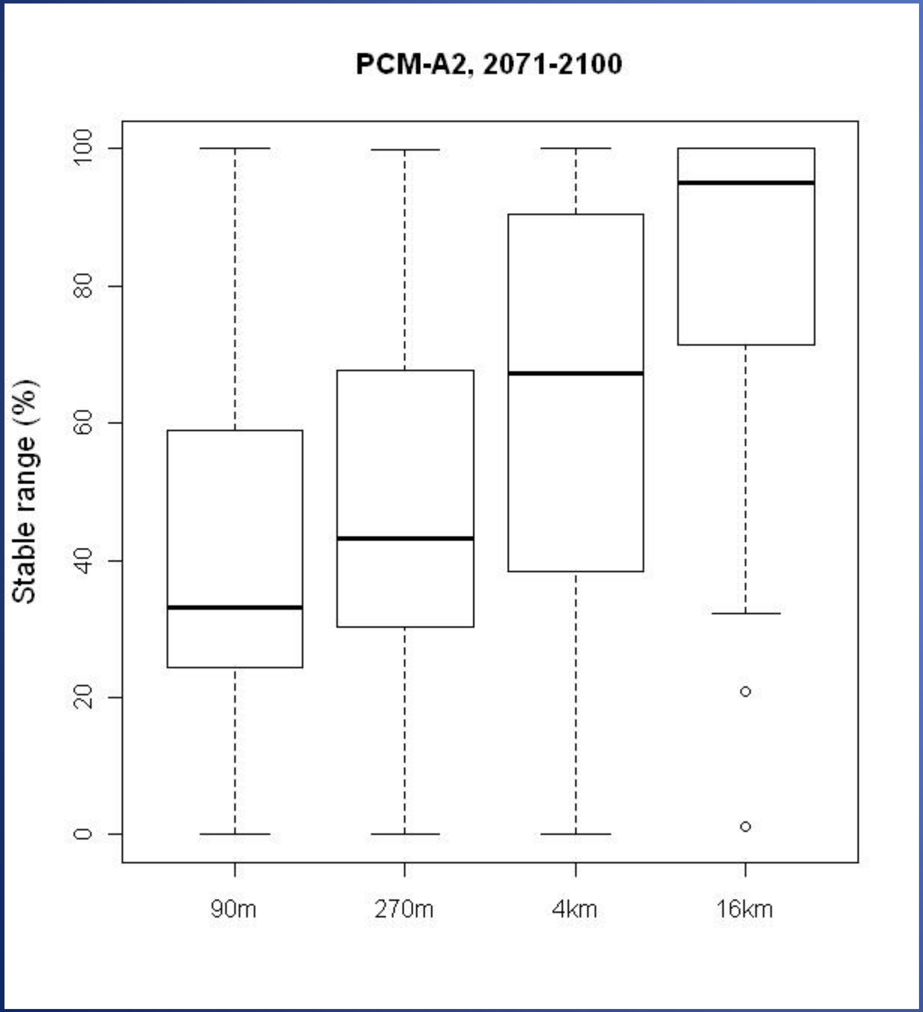


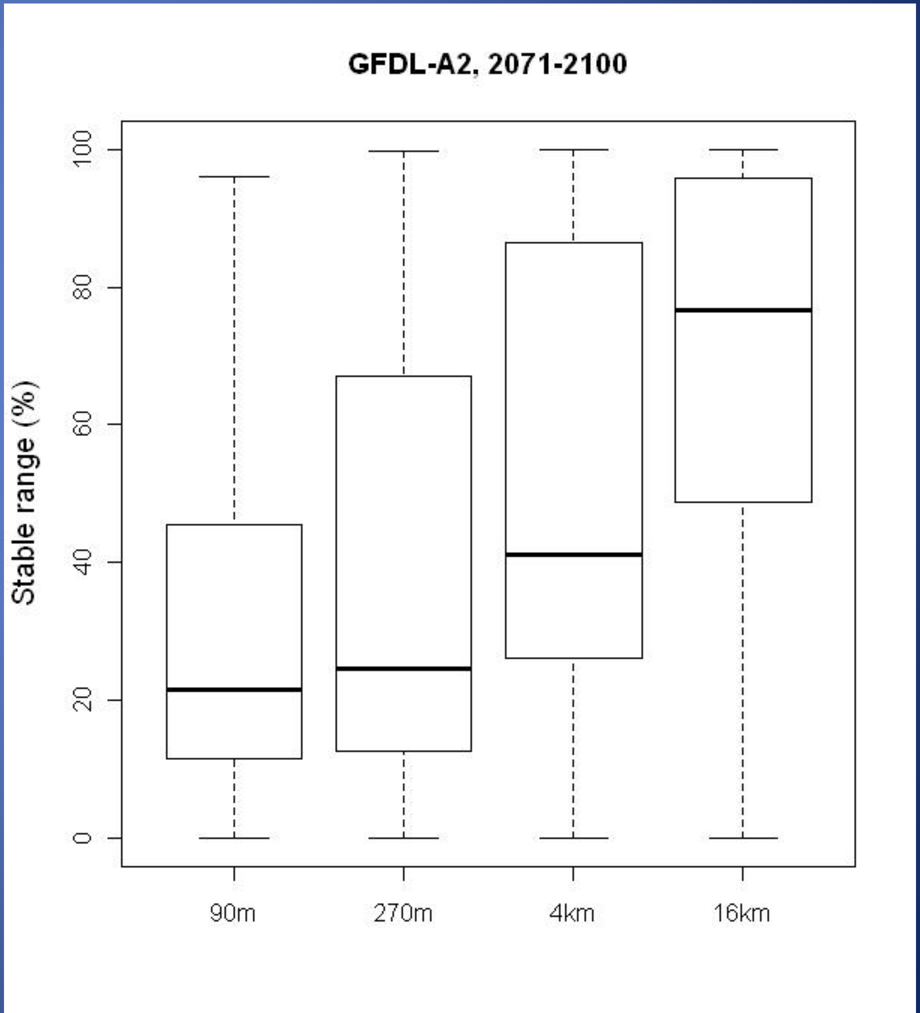

| | | Current | |
|---|---|---|---|
| | | + | - |
| Future | + | a | b |
| | - | c | d |

% Stable Range : 100* a/(a+c)

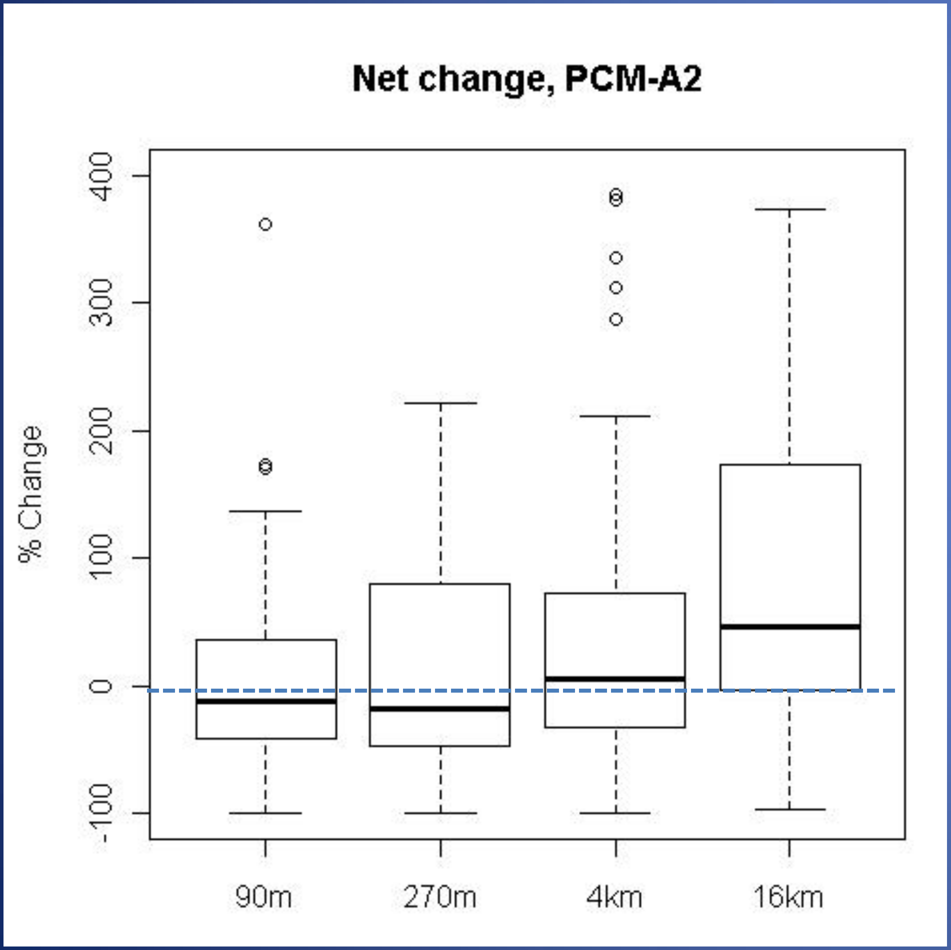
% Net change: 100*(b-c)/(a+c)

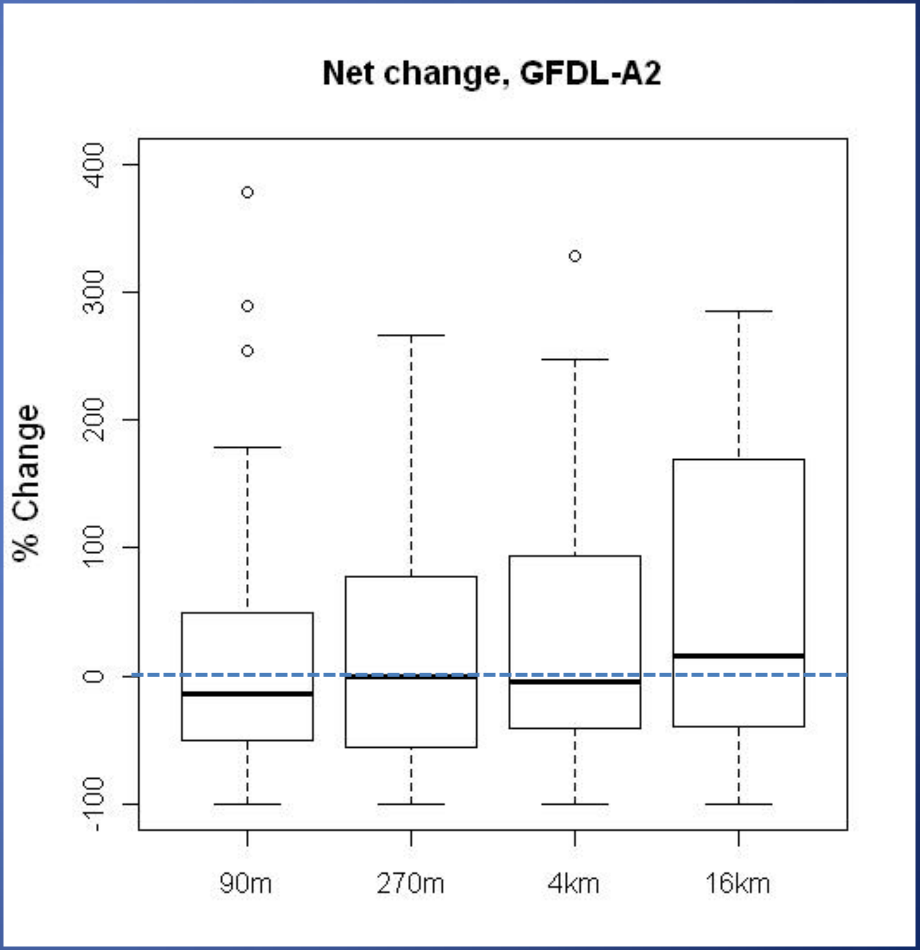
# % stable range under climate change increases with increasing grid scale



# Modeled risk of range decline decreases slightly at coarser scales



# Limitations and Next Steps

- ☹ We exclude soils, dispersal, climate extremes, [and many other factors]
- ☹ Limited number of climate models and scenarios
- ☹ Empirical case study

- ☞ May add A1F1 emission scenario
- ☞ Will add more species
- ☞ Will examine  scaling properties of topoclimates

# Summary

1. Species distribution models (SDMs) are more "accurate" but more scale-sensitive for narrowly distributed taxa
2. SDMs of current ranges are similar in accuracy and modeled range extent from 90m to 4km scales, especially for species with broad ranges, but...
3. SDMs show only moderate spatial congruence, even at relatively fine scales;
4. Local patterns are highly scale-dependent, and...
5. Modeled risk of local displacement/extinction generally increases at finer scales.

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# NCEAS Working Group

## Global Climate Change and Adaptation of Conservation Priorities

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